DESIGN AND IMPLEMENTATION OF A SITE FOR A ONE-ÅNGSTROM TEM

John H. Turner, Michael A. O'Keefe and Robert Mueller*

National Center for Electron Microscopy, University of California, LBNL B72, Berkeley, CA 94720
*Philips Electronic Instruments, Fremont, CA 94538

DESIGN AND IMPLEMENTATION OF A SITE FOR A ONE-ÅNGSTROM TEM

John H. Turner, M.A. O'Keefe and Robert Mueller*

National Center for Electron Microscopy, University of California, LBNL B72, Berkeley, CA 94720
*Philips Electronic Instruments, Fremont, CA 94538

The National Center for Electron Microscopy has recently acquired a field-emission TEM as the basis of a project to achieve a resolution of one Ångstrom. To reach this resolution, both instrumental and environmental factors need to be considered.[1,2] We have designed and constructed a new building to provide a suitable environment for this instrument, with emphasis on providing isolation from external influences detrimental to the achievement of ultra-high resolution. Such influences include mechanical vibration, temperature fluctuations, acoustic noise, and stray electromagnetic fields.

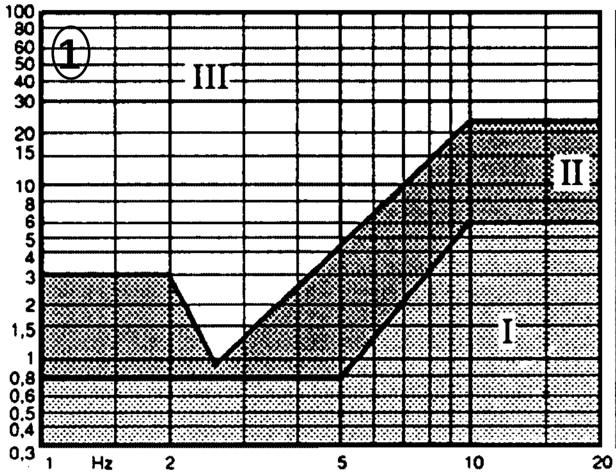
The microscope chosen for the one-Ångstrom project is a Philips CM300 Ultra-Twin equipped with a field-emission gun. Pre-installation specifications provided by Philips for this 1.7Å-resolution TEM specify maximum-allowable values for vibration levels in three mutually-perpendicular directions.[3] In the most critical direction (console left to right), vibration must remain below 0.8μm/sec in the frequency range from 1Hz to 5Hz, although allowed to rise to 6μm/sec above 10Hz (Region I in fig.1). Even when resolution is not a critical requirement, vibration must be minimized at 2.5Hz (Region II in fig.1). In the location specified for the CM300UTFEG, ground vibrations come from laboratory equipment at the NCEM and in adjacent buildings. In addition to these constant equipment-based sources, it was found that there is a variable component due to natural vibrations, known as micro-seisms, which arise from disturbances in both the atmosphere and nearby Pacific Ocean**.** In order to reduce vibration from all these sources, the CM300UTFEG microscope room was constructed around a specially-constructed slab of reinforced concrete approximately one meter thick and 3.3m by 4.2m. Three identical rooms were so constructed (fig.2).

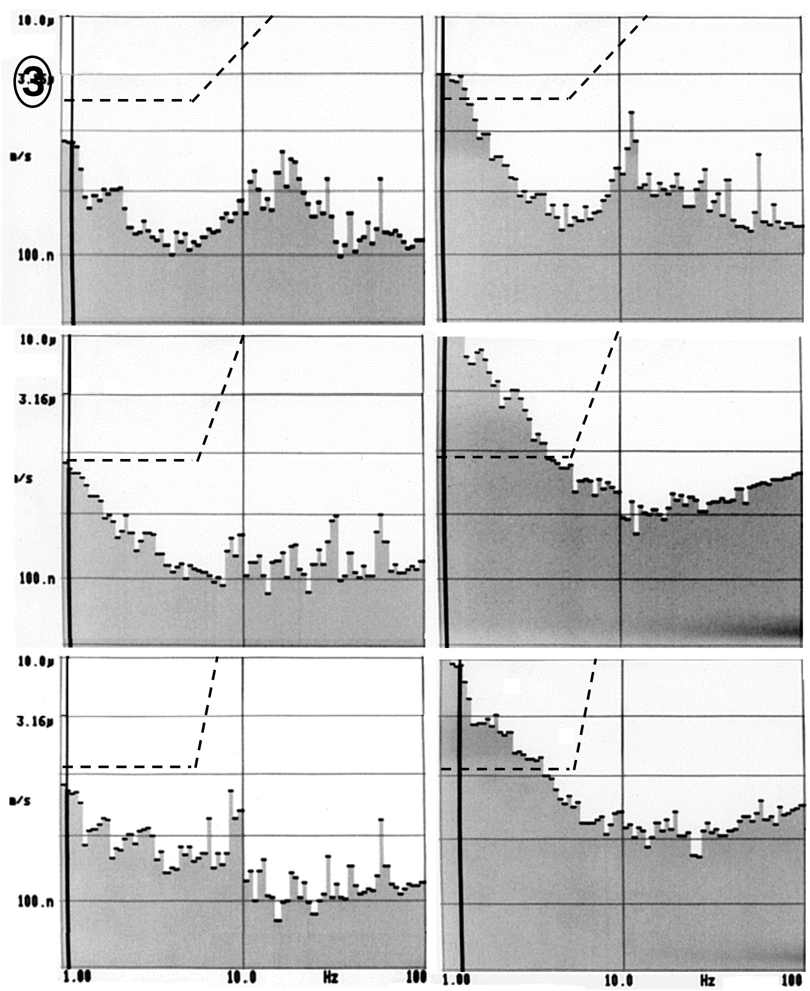
Vibration measurements were carried out using a B&K type 2515 vibration analyzer with a 8318 sensor, as supplied by Philips. It was found that measured vibration levels tracked the storm activity on the Northern California coast. For a day with above-average activity, results of vibration measurements on the slab are compared in figure 3 with measurements adjacent to the slab for the three mutually-perpendicular directions specified by Philips. All the directions show significant attenuation of vibration on the microscope-room slab, ensuring that all measured vibrations are well below allowed levels. In the vertical direction, vibration attenuation by the slab is close to a factor of three in the critical range from 1Hz to 5Hz (fig.3 top), whereas horizontal attenuation in this range is even stronger and approaches a factor of ten times (fig.3 center and bottom). Measurements reveal that vibration levels can fall to half the values shown in figure 3 under good atmospheric conditions.

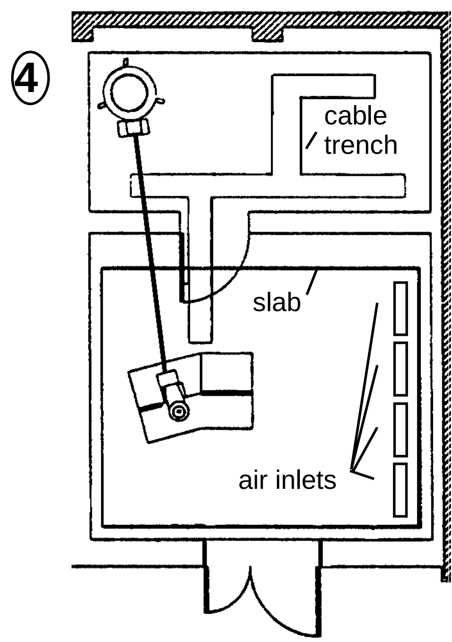
Acoustic noise has been minimized by relegating noise-producing equipment (chillers, pumps, power supplies, HT tank) to a rear equipment room (fig.4). Walls in both the equipment room and the main microscope room have been made acoustically “dead” by application of a 50mm-thick cloth-covered fiberglas sound-absorbent with an absorption factor of 0.95. In the microscope room, air currents have been minimized by arranging the air inlets along the side of the room furthest from the microscope column, forming a large plenum and providing a laminar flow down the wall and across the floor (fig.4). Individual air-handling units are provided for each microscope room to ensure adequate temperature stability with variations of less than 0.5°C per hour. To minimize electromagnetic interference, all power conduits have been routed as far as possible from the microscope column. Power and signal cables, and all cooling-water hoses, are routed between the rooms in cable trenches (fig.4).

Installation of the CM300UTFEG will soon be completed. Effectiveness of the microscope room (fig.4) and its damping slab (fig.5) will then be revealed by resolution tests (results to be presented).[4]

1. M.A. O'Keefe, *Ultramicroscopy* **47** (1992) 282-297.
2. Michael A. O'Keefe (1997) in *55th Ann Proc. MSA*, these proceedings.
3. Philips Electron Optics Pre-Installation Instruction Manual.
4. Work supported by the Office of Energy Research, Office of Basic Energy Sciences, Material Sciences Division of the U.S. Department of Energy, under contract No. DE-AC03-76SF00098.







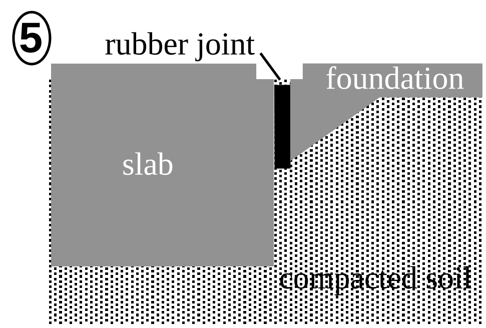


Fig. 1. Plot of allowable vibration (Region I, side to side) in μm/sec as a function of frequency from 1Hz to 20Hz[3].

Fig. 2. View of the three low-vibration slabs (3.3m by 4.2m by 1m thick) under construction.

Fig. 3. Measured vibration profiles in three directions: vertical (upper), console-left-right (center) and console-front-back (lower) measured on the microscope slab (left) compared with building foundation (right). Allowable vibration is indicated (dashed lines). Note: log scale vibration axes run from 31.6 nm/sec to 10 μm/sec and frequency axes run from 1Hz to 100 Hz.

Fig. 4. Plan of high-resolution TEM room, showing location of slab, air inlets, and sunken cable trench.

Fig. 5. Cross-section drawing showing slab/foundation interface with isolating rubber gasket.